Futures stock market pricing by the use of the U-Mart system as an artificial intelligent market simulator[1]

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1. The U-Mart system approach to the futures stock market

In the final quarter of the last century the **futures** market operation became a saliently conspicuous factor for the global economy. Many econophysists however even now are interested in prices formation and distributions of the spot markets partly due to their limitational data availability. The U-Mart System (Shiozawa et. al. 2008) is an artificial intelligent market system to implement a virtual **futures** market with reference to the actual stock price index arbitrarily chosen, by the use of agent-based simulation techniques.[2] This system, mutatis mutandis, contains a spot market trading as a special case.

It is also noteworthy to point out two outstanding features of the U-Mart system. First of all, any agent, either machine or human, does not presume a certain personal rational demand function in advance (LeBaron 2006, Koyama 2008). Secondly, this system adopts a hybrid approach in a sense that a human agent can always join in the machine agent gaming setting. The latter is a technological feature, a new network innovation of artificial intelligent market system. The former is featured by an alternative approach to the neoclassical method.

The implementation of rational demand function into the exchange system, the kinds of Santa Fe (LeBaron et. al. 1997) attempt to operate its artificial market, must actually be not realistic, because the market fluctuations always enforce each agent to update its own demand function. Agents are faced with updating or reconstructing their demand function each session of trading. In front of these situations a kind of neoclassical computation should not be effectuated. In the U-Mart system, therefore, any machine agent behaves on his technical analytical base. Each agent also uses a so-called technical analysis to estimate his pricing on his own empirical base. This is just a human wisdom. Otherwise, it may be put a heavy strain on the human brain or computer.

Originally in 1998 U-Mart Project started as V-Mart(Virtual Mart). Now it however becomes called

[1] We are grateful to have discussions with Mario Morroni, Gulio Botazzi in Pisa, and Oliver Hein in Frankfurt on AI stock market and simulations.
[2] By futures market, gambling entertainment is associated with U-Mart simulation because agents, either machine or human, must finally settle his trade balance by the use of the spot price at the end of trade(delivery date=the final day).

Unreal Market as an Artificial Research Test-bed. The U-Mart Project has just published an English textbook (Shiozawa et. al. 2008) as one of Springer Series on Agent Based Social Systems in Spring 2008. The development of the U-Mart system during these 10 years rather was mainly engineers-driven(http://www.u-mart.org/html/index.html). Now the U-Mart system is internationally recognized as a good platform for AI markets.
The U-Mart project has had a policy to publicize all the program sources. Many reports of AI market simulations often let us known without publicize how to work the AI. We believe that the results of market simulations by secret sources may be almost worthless.

In this article, we try to argue several economists-suggested issues around the AI markets discussed in the current papers.

As stated soon, the history of Japanese merchant technology was of supreme excellence to be the first in the world to construct a complete futures stock market. The TSE thus inherits our historical custom to use the traditional terms for trading such as Itayose and Zaraba(Taniguchi et. al. 2008). Each market method must similarly retain its own historical difference. A further examination on these differences will clarify that the market method is so institutionally sensitive. Theoretically speaking, zaraba in the TSE is a kind of continuous auction. But this auction method is bound by TSE's own rules and customs. So the TSE even now rightly employs the term "zaraba auction" instead of a continuous auction (http://www.tse.or.jp/english/faq/list/stockprice/p_c.html). The details are given in a later section.

It is interesting to verify how zero-intelligent agents (Gode and Sunder 1993) can earn not only in the spot market but also in the futures market. This subject often is argued elsewhere. We can easily show that the U-Mart system could be a test bed to analyze the behaviors of zero-intelligent agents both in spot and futures.

On the contrary, it is also interesting to verify certain intelligent agents who definitely decide their strategies on their own analytical estimation from the data given them. For instance, we analyze the behaviors of the agents who employ a certain technical analysis by a successive discrete choice analysis, the so-called multi-nomial logit utility modeling. This modeling gives a mode choice for agents. In the market, mode choice must be restricted to three distinct modes: sell, buy, and nothing. By this estimation of agent utility of mode choice, thus, each agent may decide its own strategy.

Suppose that all the agents by accident happened to be the same analytical agents by the fact that they employed the same analysis on the same data. This eventually amounts to the situation where any trade never happens because they adopt the same mode. All sell (or buy) cannot generate trading

We then show that the U-Mart System can easily produce the situations of "nothing happens." Finally, we show that a little perturbation of a strategy parameter in the strategy could generate any trading even if all the agents should employ the similar but the same strategy in a sense that some slightly changed parameter are found among the similar strategies. A little perturbation of a similar strategy may have a good effect to make the dealing effective.

In the above we only discussed a few applications of the U-Mart system to examine our economic issues of AI market. In the near future, we must discuss more applications by the use of U-Mart system.

2. A historical excursus on our stock market

The modern Tokyo Stock Exchange, TSE inherits all the traditional terms from Osaka Dojima Rice

Exchange officially approved by Shogun government since 1730, which was taken for granted the first complete futures market in the world.[3] The Dojima Exchange was quite a perfect system where a so-called circuit breaker was originally implemented at the start. It is said that there were about 1,000 trading experts (brokers) always working in Dojima Exchange. This exchange continued to play an essential role to confirm the standard rice price for 30 million population in 18th C. in Japan. Thus many traditional terminologies and customs still are alive in the modern stage of TSE.

Osaka Dojima future rice exchange without rice

In fact, these methods were actually our historically traditional methods for rice or other commodities exchanges. In the modern TSE, two different clearing methods are still now employed: *itayose* and *zaraba*. Many economists quite love to use "auction," even though the market mechanism can often not be identified with a simple auction as utterly irrelevant to any institutionally complicated design. If we should favor the term "auction," for convenience, we could give a certain correspondence between our traditional method and a contemporary term of auction:

A) The itayose method: this can in principle be specified as double auction on a single good to trade multi units, in the sealed bid format. This is usually called "batch auction."
B) The zaraba method: this can in principle be specified as double auction on a single good to trade multi units, in the open bid format. This is called "a continuous auction."

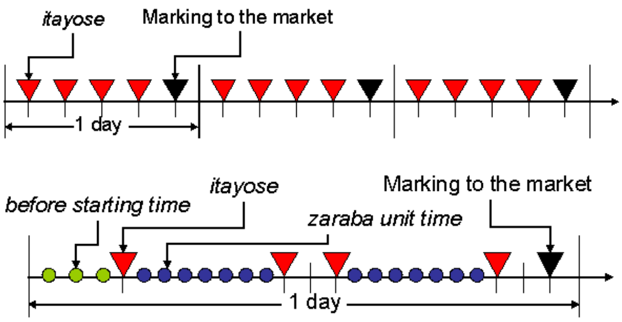
However, we have a definite reason why we should use our traditional terms like itayose and zaraba. The market always is accompanied with a special set of historical rules and institutions. This fact suggests that a particular type of auction has a class of a number of variants. In particular, our custom of trading decisively depends on our institutional designs. A brief look on zaraba could provide us with a view of institutional dependence of market trading.

In the TSE, the Itayose method is employed to decide opening and closing prices; the Zaraba method is utilized during continuous auction trading for the rest of the trading session.[4] In the commodity market, the itayose often is used in Japan. Itayose trading is conducted at the opening/closing session morning/afternoon, while zaraba trading is conducted in-between the first-second itayose and the third-forth itayose. Figure 1 shows the time structures between the U-Mart

[3] There were seen several well organized markets for spot trading in Europe still in 1531 in Antwerp, and in 1568 in London. In these day Japanese merchants also very much loved the same spot trading.

[4] In the Itayose custom, the initial price at the resumption after a trade halt happening is to be established by this method. So this is employed at the opening session. At the present times, this method also is applied to the closing session. Usually in TSE, the itayose method is utilized at the opening and closing prices for the morning and afternoon sessions. In addition, the price when a special quote is indicated is determined by the itayose method. While in the Zaraba custom, TSE applies the zaraba method to matching at a continuous time In the rest of the day excepting the opening and closing sessions.

itayose server and the U-Mart zaraba server(Ono et. al. 2008).



3. An important notice on the shapes and performances of market mechanism

We give a reason why we should prefer our traditional word “itayose/zaraba” to “auction.” We take an example of zaraba. According to auction theory, zaraba can be classified into the category of continious auction. A realization of “continuous double auction” however requires a bundle of institutional settings to make its price formation smooth. It is needless to say that such a bundel efficiently was desinged by many historical factors of the counrty. This fact also is applicable to fish markets. Ancona’s fish market setting is quite different from Marseille’s fish market. See Kirman and Vrined (2000). In other words, double auction actually wears a various cloth. The institutional arrangement of double aouction must not be unique.

Trading priorities:[5]
It is wellknown that double auction mechanism is desinged by the following priorities for trading:

- Market order priority
- Higher price priority(Buy); Lower price priority(Sell)
- Preceding offer first priority(time preference)

Institutional devices/links:
We show that zaraba is an sample of institutional linked market. The trading priorities must be associated with the following institutional devices:

- Price movement limit
- Special bid and ask price
- Updating the price movement limit
- Stop high/stop low

These institutional devices can gurantee to make price formation smoothly in the stock exchange system. The performance of the trading mechanism decisively depends on its own institutional settings.

An agent only intermittently is arriving at the market. The arrival rate can be changing due to various reasons. Furthermore, an order of the agent ex ante is unknown even about the mode for trading: sell, buy, or nothing. Thus it becomes a very important task of the stock exchange system to induce all the agents to decide their trades by exhibiting a feasible price range under monitoring where the next candidate should arrive. The way how to exhibit the range is a kind of institutinal technique linked to a historical custom as shown in Table 1.

The limit exhibited are not always succesful to accept bids and asks within its own range. Either special bid or ask price then are to be suggeted noticeably if the prices exceed over the limit. The

[5] As for order, we have two kinds. One is limit order, the other is market order. Market order is the order traded by any contracted price agreed in the exchange system.

exchange system must simultaneously update the price movement limit. In Table 1, we have no arriving bid within the given price movement limit. The stock exchange then annouces the special bid and update the limit to accept this bid. Without this kind of iteration based on such an institutional arrangement, the quotations could not be feasible. The specification of the limit may be multiple if we have a set of long tails of bid/ask distributions. The result of contract may depend on a particular institution and rule. Thus the excahnge system actually needs a refined skill to set out andupdater manage the price movement limit.

Even such an implementation of cntract guidance could not necessarily gurantee a normal trade if we should be face with a rapid fluctutation of ask/bid. In this istuation, the exchange system must eomploy the rule of Stop High/Stop Low to interupt the current trades. This notion lead to bringing a circuit braker system of the exchange.

Ask	Price	Bid		Ask	Price	Bid	
82	1798			82	1798		
73	1793			73	1793		
38	1779		The restricted	38	1779		
44	1778		range	44	1778		updating
91	1776			91	1776		the range
	1770	67			1770	67	
	Special Bid				Normal Bid		
Ask	Price	Bid		38	1779		
246	1770 Special			44	1778		
				91	1776		
					1770	67	

Table 1

Price movement limits on the bid and asked prices, i.e., a range in prices is set out in the following manner by the practical custom(TSE): under 500yen, within 5yen;under1000yen, 10yen; under 1500yen, 20yen; under 2000yen, 30yen; under 3000yen, 50yen; under 5000yen, 100yen; under 1000yen, 200yen; below a long list to be continued. In Table 1, the prices fuluctuate aorund 1500-2000yen. So the price movement limit is taken within 20 yen: from 1773 to 1779.

It is used to set the price contracted at the end of the previous day as the marker price of the day. Based on the marker price, the rule of stop high and low regulates a violent price variation springing out of the marker price to sotp the trade. Aaccording to the following variation rule(TSE): under 100yen, ±30yen; under 200yen, ±50yen; under 500yen, ±80yen; under1000, ±100yen; under 1500yen, ±200yen; under 2000yen, ±300yen; under 3000yen, ±400yen; below a long list to be continued.

4.Zero-intelligence tests in the U-Mart system

The U-Mart system are mainly designed for futures market trading. In this trading, either machine agents or human join to create a successive sequence of futures prices, with reference to a given real spot market prices arbitrarily chosen. Due to the property of futures market, the settlement must be done at the final delivery date by employing the real spot price. This contains some entertaining elements of gamble. Furthermore, if some additional efforts were given to remove the regulations for futures market trading, we could imitate a trade for the spot market. In other words, the spot market can be derived as a special case of U-Mart system.

In the U-Mart system, default loaded agents with technical analyses are as follows:

- TrendStrategy
- AntiTrendStrategy
- RandomStrategy
- SRandomStrategy(S means using spot prices)
- RsiStrategy(RSI: Relative Strength Index)
- SRsiStrategy
- MovingAverageStrategy
- SMovingAverageStrategy
- SFSpreadStrategy
- DayTradeStrategy

A mixture of some of the above fundamanetal strategies may be feasible. Every year we calls for collecting new machine agent to hold a competition as an U-Mart promotion eveent. We cite a part of the U-Mart random strategy's JAVA program.

```
package strategy;
import java.util.*;
public class TestStrategyextends Strategy {
private Random random;
private final int widthOfPrice= 20;
private final int maxQuant= 50;
private final int minQuant= 10;
private final int maxPosition= 300;
private final int nominalPrice= 3000;
public TestStrategy(int seed) {
random= new Random(seed);} /* a random instance generated
<<skip the several program lines:
Method of making order/Scan a well defined latest futures price
Cancel decision (to be continued)>>
while( true ) {
order.price= prevPrice+ (int)(widthOfPrice*random.nextGaussian());
if ( order.price> 0 ) break;
}
order.quant= minQuant+ random.nextInt(maxQuant-minQuant+1);
message(
Order.buySellToString(order.buysell) +
", price = " + order.price+
", volume = " + order.quant+
" (prevPrice= " + prevPrice+
" )"
);
return order;
}
```

Here we focus on the random strategy agent as one of default machine agents. The random strategy means a strategy of employing the simultaneous random move on mode choice(sell or buy) and limit order(price and quantity). The choice entirely depends on the pseudorandom number generation by server computer. Thus we canutilitze our random strategy as the zero intelligent agents. We can then conduct in the spot market two kinds of zero intellignet simulation. One is as for the futures market, the other is as for the spot market.

In a long history of the U-Mart experiment as for the futres market, we became familiar with the working or role of random strategy. We eventually have had an emprical rule that the random strategy are not defeated by many other strategies, and this may be a winning strategy when all other agents than the random are similar. This experiment is quite easily run only by the standalone type simulator of the U-Mart system. The author strongly recommends the readers to conduct this elementary experiment. A repertoire for market simulation must be expanded to discover new heuristics in the market trade properties. Consequently, we are used to use this strategy as a test starategy, i.e., to match a new machine with this strategy.

4.1 Random strategy's earning ability in the futures market

Now we refer to the results of simulation. We have employed the itayose server in this simulation.[6] Firstly, we compare the capability of random strategy with the other default machin agents. Here we note that we have two kinds of random strategy only with a slightly change wheter the previous price is set the futures price or the sopt price.

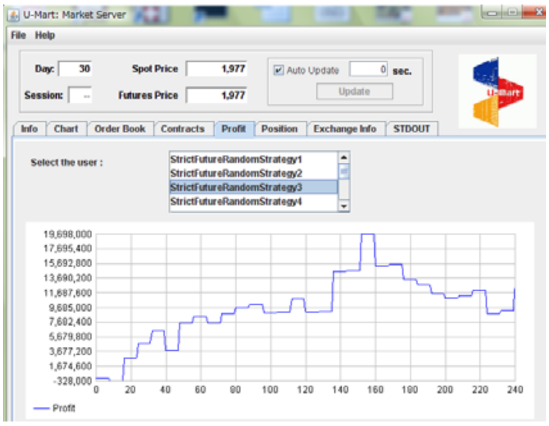
	MemberID	Sell	Buy	TotalSell	TotalBuy	Cash
H	h91	0	0	0	0	1,000,000,000
H	h92	0	0	0	0	1,000,000,000
H	h93	0	0	0	0	1,000,000,000
H	h94	0	0	0	0	1,000,000,000
H	h95	0	0	0	0	1,000,000,000
H	h96	0	0	0	0	1,000,000,000
H	h97	0	0	0	0	1,000,000,000
H	h98	0	0	0	0	1,000,000,000
H	h99	0	0	0	0	1,000,000,000
H	h100	0	0	0	0	1,000,000,000
M	TrendStrategy	0	0	0	0	1,074,520,000
M	AntiTrendStrategy1	0	0	0	0	913,029,000
M	AntiTrendStrategy2	0	0	0	0	991,613,000
M	RandomStrategy	0	0	0	0	885,616,000
M	SRandomStrategy0000	0	0	0	0	1,064,238,000
M	SRandomStrategy0001	0	0	0	0	1,009,764,000
M	SRandomStrategy0002	0	0	0	0	1,052,480,000
M	RsiStrategy	0	0	0	0	913,978,000
M	SRsiStrategy1	0	0	0	0	972,943,000
M	SRsiStrategy2	0	0	0	0	1,008,824,000
M	SRsiStrategy3	0	0	0	0	973,959,000
M	MovingAverageStrategy	0	0	0	0	991,410,000
M	SMovingAverageStrategy1	0	0	0	0	997,527,000
M	SMovingAverageStrategy2	0	0	0	0	1,010,558,000
M	SMovingAverageStrategy3	0	0	0	0	1,004,198,000
M	SFSpreadStrategy1	0	0	0	0	1,106,422,000
M	SFSpreadStrategy2	0	0	0	0	1,088,026,000
M	DayTradeStrategy1	0	0	0	0	974,903,000
M	DayTradeStrategy2	0	0	0	0	965,992,000

[6] In the zaraba server, we do not still have any other better machine strategy which could adapt to the zaraba environment than the random machine. So we cannot compare the capability of random machine with the other machine strategies.

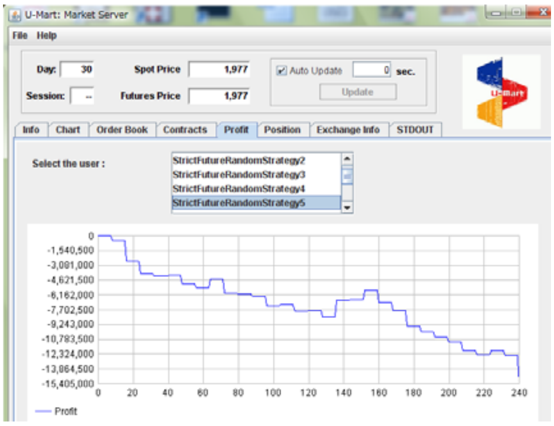
In this smiulation, we also have no human subject entries. All the machine agents have 10 billion yen as their initial holdings. Here we arranged 4 random strategies: RandomStrategy; SRandomSTrategy0000; SRandomSTrategy0001; SRandomSTrategy0002. Except for RandomStrategy, the other three random strategies earned more thant their initial holdings. RandomStrategy0000 is ranked the top 4 of 19machine agents. Thsu our empirical rule on the random player is found.

4.2 Random strategy's earning ability in the spto market

The U-Mart system does actually not have a test bed prepared exclusively for the spot market. But this system can mutatis mutandis imitate the spot market trading. If we removed the setting for the market clearance at the final delivery from the futures market program, we could realize the spot market dealing in the futures market of the U-Mart system. The unrealized profit of each day in the futures market is regarded as profit in the spot market. So next we show the random strategy dealings in the spot market by the use of zaraba server. Here we designed the match of consisting of 10 random strategy agents only.[7] We show the transition of each agent's earning. We have seen that there are generated a set of winning/losing agents.



A winning agent



A losing agent

5. Applying the Hazard modeling to the market mode choice

So far we never tried to formulate a market agent behavior in the U-Mart project. In this section, we give a rough sektch on an agent modeling in the market exchange. The agents in the market can

[7] We fabricated a new agent called the StrictFutrueRandomStrategy which never cleared the position balance at the delivery date in the futures market. This strategy can realize a virtual spot dealing in the futures market platform.

estimate their data of market dealing to derive their utiliy functions on their successive choices.[8] It is noted that dealing has three modes of order[sell, buy] and nothing. So an agent commits himself/herself to a mode choice. Thus we apply the hazard modeling to the agent market behavior.The method we are just about to utilize is the hazard modeling which is often used in the maketing research to estimate customer demands. This modeling is closely rrelated to the multi-nomial modeling of utility. A multi-nomial logit modeling could provide all the agents a good prediction on macroscopic movements of futures price. However, if the all the agents followed this way, and the risk attitude were the same, all the moves would be the same. In the market, we have no trade. This may be a paradox which a kind of rational expectation school can not solve.

It is improtant to know when the order of an agent is generated. This date could be predcited if we used the hazard modleing to calculate the hazard rate. Agent must decide when he/she has an order, i.e., either ask or bit[limit order] or market order. The probability which agents have order earlier than at session *t* can be defined:

$$F(t) = \Pr(\text{node interval} \le t) = \int_0^t f(s)ds$$

The survival probability which the remaining agents have order later than at session *t* can then be defined:

$$S = 1 - F(t)$$

The hazard rate which order just happens when there is no order until at session *t* (this rate is not probability):

$$h(t) = -\frac{d\ \ln(1-F(t))}{dt}$$

$$F(t) = 1 - \exp\{-\int_0^t h(s)ds\}$$

$$f(t) = \frac{dF(t)}{dt} = h(t)\exp\{-\int_0^t h(s)ds\} = h(t)S(t)$$

In the U-Mart system, as time goes by, the spot prices can be specified at any not-censoring session in the following manner:

$$(t_1, x_1), \cdots, (t_N, x_N)$$

In this special case, we have a simple form of the hazard rate:

$$h(s,x) = \lambda(s)e^{\beta x}$$

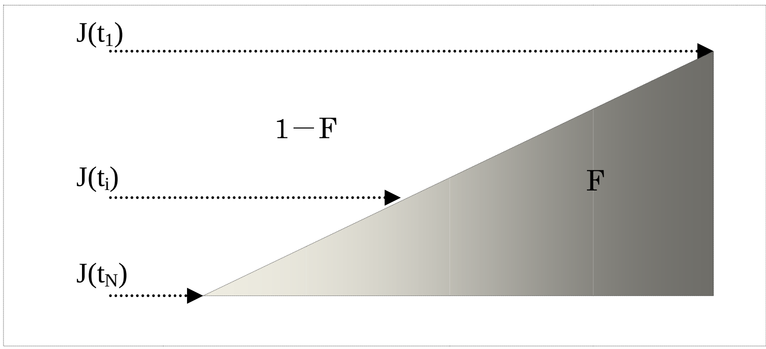
x can be replaced with the difference of spot and future price :

$$x = f(\bar{x}^s - \bar{x}^f)$$

Sometimes, this may be more sophisticated in terms of moving averages of both sequences.

Let *J*(*t*) be the group of agent *j* who never yet has order at session t. It then follows $j \in J$.

[8] A successive choice requires utility function. But this utility of Luce type contains a different meaning from a neoclassical utility.



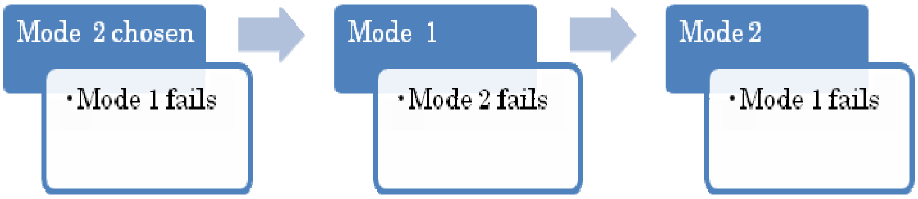
The probability which any agent *i* in *J*(*t*) will have an actual order will be as follows.

$$\Pr(i \mid t_i) = \frac{h(t_i, x_i)}{\sum_{j \in J(t_i)} h(t_i, x_i)} = \frac{e^{\beta x_i}}{\sum_{j \in J(t_i)} e^{\beta x_j}}$$

This shows how often the rate which the agent who never had orders converted to have an order at session *t*. This formula eventually amounted to the multi-nomial logit choice model formula. But the above formula has nothing to do with some discrete utility modeling.

Traders are just allowed to have the three exclusive strategies of Sell, Buy, and Nothing. We have the following binary discrete choice

- Mode 1 : have order[Sell or Buy]
- Mode 2: have nothing



The change of the hazard rate is β. βx may be interpreted with expected utility of the choice. x suggests a kind of cost accompanying a choice mode *j* done:

$V_{\text{mode } j} = \beta x$ for *j*=1,2

This is the simplest form of multi-nomial logit utility on the agent market behavior. It is noted tha x may be defined as follows:

$x = f(\bar{x}^s - \bar{x}^f);\ f'(x) > 0$

If $\bar{x}^s - \bar{x}^f > 0$, a normal dealer may buy.

If $\bar{x}^s - \bar{x}^f = 0$, a normal dealer may have nothing.

If $\bar{x}^s - \bar{x}^f < 0$, a normal dealer may sell.

Vice versa for a contrarina.

In the U-Mart system, a multi-nomial logit modeling by itself can provide a technical machine strategy.

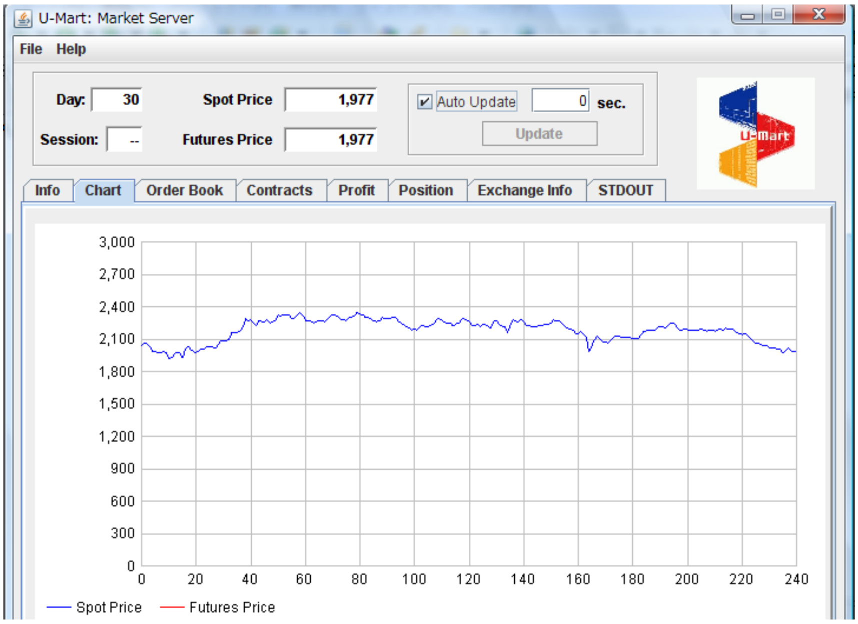
6. Heterogeneity in the market：a slight change could give rise to a feasible dealing form nothing

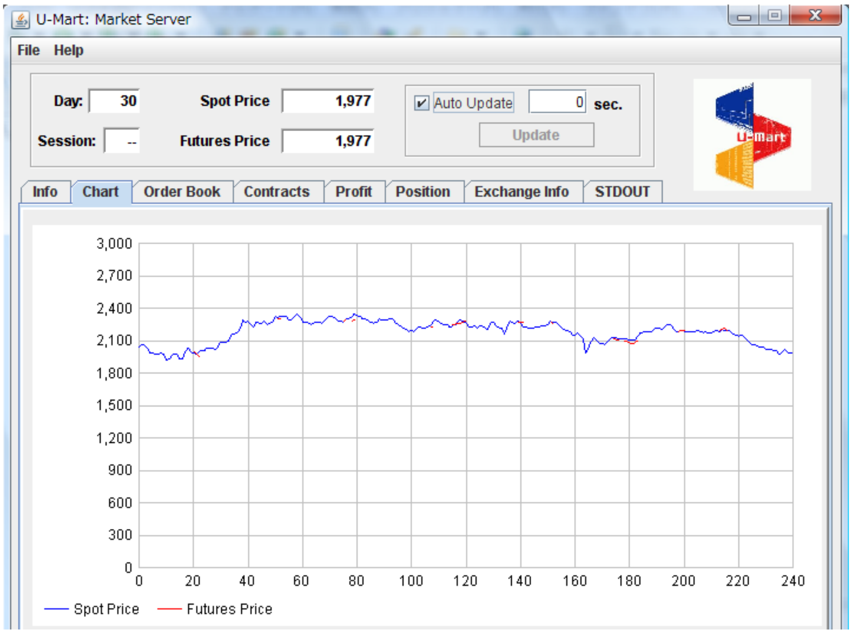
A set of agent type distribution must be crucial for price formation. If all the agents should be of similar type, they should behave similarly. All sell or buy must hold. It does not then hold any dealing. We can check how this possibility could be eliminated by the use of U-Mart simulation. In order to do this, we here pick up the SRsiStrategy (Shiozawa 2008,142) .

> We summarize this strategy. This agent obtains the spot price, and uses the futures price if the spot price cannot be obtained. Based on the value obtained, RSI is calculated.
>
> RSI = upSum/(upSum+downSum).
>
> Here upSum stands for the sum total of price fluctuation when the price rises, and down Sum stands for the sum total of price fluctuation when the price falls. This agent offers a sell order if the RSI value is higherr than the upper limit(1.0 –edge band value), and offers a buy order if the RSI value is lower than the lower limit (edge band value). The order price is determined using Gaussian with a focus on the latest spot obtained. The divergence of price distribution is determined with the field varibale 'widthOf Price.'The order volume is randomly determined between minQuote and maxQuote.

Now we introduce a slightly changed parameter into our SRsiStrategy of default setting where the program line reads:
private final double edge = 0.3; // Edge band value of RSI method.
We call our variant SRsiStrategyVar where the parameter of edge value is changed from 0.3 to 0.9 where the program line is newly rewritten:
private final double edge = 0.9; // Edge band value of RSI method.

As easily seen, only 10 SRsiStrategy default agents cannot creat a feasible trading, because all the agents have the same mode: All buy, All sell, or All nothing. Next we replace the 5 default strategy agents with 5 variant agents who have only a different edge band value. We can then achieve a feasible trading!!





References

LeBaron,B.(2006), Agent-based Computational Finance, in L. Tesfatsion and K.L.Judd (eds.), Handbook of Computational Economics Vol.2. Agent-Based Computational Economics, pp. 1187 – 1272.

LeBaron, B. (1993), W. Brian Arthur and Richard G. Palmer, Time series properties of an artificial stock market, Journal of Economic Dynamics and Control,Vol 23, No. 9, pp 1487-1516, 1999.

Gode D.K.and Sunder S.(1993), Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality, *The Journal of Political Economy*, Vol.101, No.1, pp119-137.

Kirman, A. and Vrined, N.(2000), "Evolving Market Structure: A Model of Price Dispersion and Loyalty for the Marseille Fish Market", in Interaction and Market Structure, Edited by Delli Gatti, Gallegati and Kirman , Springer Verlag, Heidelberg.

Koyama Y., Ishiyama K., Kaneko H., Ono I., and Matsui H.(2007) Using U-mart Sysytem for the lecture of economics, in T. Terano, H. Kita H. Deguchi and K. Kijima(eds.), Agent-basedd Approached in Economic and Social Complex Systems IV, Springer, Tokyo.

Koyama Y.(2008), U-Mart as a new generation artificial market, *Evolutionary and Institutional Economic Review*, forthcoming.

Ono I., Sato H., Mori N., Nakajima Y., Matsui H., and Koyama Y.(2008), U-Mart System: A Market Simulator for Analyzing and Designing Institutions, *Evolutionary and Institutional Economic Review*, forthcoming.

Shiozawa, Y., Nakajima, Y., Matsui, H., Koyama, Y., Taniguchi, K., Hashimoto, F. (2008), Artificial Market Experiments with the U-Mart System, Springer Series on Agent Based

Social Systems, Vol. 4, Springer, Tokyo, 161pp.

Taniguchi K., Ono I. and Mori N., Where and Why does the Zaraba Method Have Advantages over the Itayose Method?- Comparison of the Zaraba Method and the Itayose Method by Using the U-Mart System –(2008), *Evolutionary and Institutional Economic Review*, forthcoming.